STRUCTURE TRIAGE DURING WILDLAND INTERMIX FIRES

STRATEGIC MANAGEMENT OF CHANGE

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ABSTRACT

This research project analyzed the factors that influence the survivability of structures located in wildland/urban intermix areas. The problem was lack of a standardized, systematic procedure for affecting structure triage. The purpose of the project was to produce a simple change in managerial operations using a short checklist for structure triage during a wildland fire.

This research employed both historical and action research (a) to identify attributes of land and buildings that compromise firefighter safety during structure protection operations, (b) to identify those physical features of a structure and its environs that serve as reliable predictors of structure survivability during wildfire, (c) to assess which survivability predictors are of practical value in performing structure triage, and (d) to develop guidelines that help direct the actions of firefighters undertaking structure protection in limited resource situations involving uncontrollable wildland fires.

The principal procedure employed was review of instructional materials and wildfire case studies focusing on structure protection in wildland/urban intermix areas. Data were complied in table form to facilitate comparison of survivability factors discussed in the literature.

The major findings of this research were that a small number of factors could be used to accurately predict structure survivability during wildland fires. Principal among those factors were accessibility, roof construction, defensible space, and angle of adjoining terrain. The research findings were incorporated into a checklist appropriate for field use during structural/wildland fires.

The recommendations, resulting from this research, included (a) incorporating use of the checklist into operational procedures, (b) training fire officers in the use and limitations of the

checklist, (c) providing periodic updates to the checklist, and (d) using the checklist in pre-incident planning to better inform the fire department and property owners of risks involved with building in or near wildland.

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INTRODUCTION

The Hopkinsville Fire Department (HFD), years ago, recognized the severe wildland fire hazards posed to the structures on and by the forest and brush land in its response area. To the extent allowed by available resources, HFD actively participates in community planning, public education, and hazard-reductional programs aimed at mitigating these hazards. In spite of such efforts, fire officers will face extremely difficult decisions when the inevitable, uncontrollable wildland fire threatens structures too numerous for response forces to protect. A major problem those officers would face today is lack of a standardized, systematic procedure for an effective structure triage.

The purpose of this research project was to develop a simple, short checklist fire officers could use when doing structure triage during a wildland fire. Historical and action research methods were used to answer the following questions:

1. What attributes of premises i.e., land and buildings located in the intermix zone, reduce firefighter safety to an unacceptable level?
2. What physical features of a structure and its environs are reliable and accurate predictors of its survivability during a wildland/urban intermix fire?
3. Which of the most significant of those predictors can be quickly evaluated with reasonable accuracy and precision?
4. What evaluation results suggest a structure (a) should be protected, (b) should be written off, or (c) will probably survive without active structure protection?

BACKGROUND AND SIGNIFICANCE

Current demographic changes in Hopkinsville/Christian County, Kentucky, continue the trend of change of the last decade in at least one way important to the fire service. Homes and apartment buildings are being built at an excelerated rate in the wildland/urban intermix areas. Those areas comprise the entire undeveloped portions of Christian County, a rural, high country area consisting of narrow river valleys delineated by high hills in the northern region. With existing build out, less than fifty percent of projected, approved development, and with the average annual population increase in the county running 2.3 percent (1.5 times the Kentucky growth rate), the probability for a wildland fire, that threatens structures multiples annually (*CACI*, 1994).

The Hopkinsville Christian County Fire Chiefs have stated publicly that the questions with which the public should concern itself are not **if** major structure losses will occur from wildland fires but **when** such losses will occur. They admonish residents that “there are enough resources to protect every threatened structure, hard decisions will be made as to when and where intervention will occur” (Hopkinsville/Christian County Fire Mitigation Program, n.d., p. 2). The Chiefs point out to owner apathy and unwillingness to practice good structure protection behaviors (e.g., defensible space) as the principle reasons for their prediction.

As part of the implementation of the Hopkinsville/Christian County Fire Hazard Mitigation Plan for New Construction (Board of County Magistrates, 1992) HFD and the Kentucky State Forest Service (KSFS) identified wildfire hazard ratings for subdivisions. KSFS determines those ratings through an assessment of fuel types and physical characteristics that affect wildfire behavior; the ratings are not based on structure types or features. Meager resources have not allowed HFD to accomplish pre-fire planning for individual structures, which planning would show the defensibility of the structure during a wildland fire. Absent such pre-fire plans, HFD responders will likely be forced to do structure triage during fires in wildland/urban intermix areas. Given the rural (rather than urban) character of Christian County (population approximately 70,000) and the topography described above, Winston's (1994) use of the term "structural wildland intermix" is fitting.

The nature and objectives of structure triage and the need for change are described in the manual for the National Fire Academy's *Strategic Analysis of Fire Department Operations* course as follows (*National Fire Academy* [NFA], 1991).

> "Triage" originates from a word meaning to divide into three parts. Basically, it amounts to 1) eliminate the hopeless; 2) ignore the unnecessary; 3) deal with the rest. While we, as firefighters, hesitate to write off any threatened structure, triage is necessary to prevent futile waste of effort. Trying to save more than you realistically can, might very well result in the loss of everything, including homes you could have saved. Forget the structures that are impossible or too dangerous to defend; leave those that are too well involved to save. Ignore, for now, the structures needing little or no protection. Concentrate on seriously threatened but savable structures. What is or not feasible depends on the overall situation: what the fire does, and what resources you have (p. 61).

NFA (1991) also asserts that the above guidance lacks the specifics needed to do a real-world triage. What criteria does a fire officer employ to decide that a structure is impossible or too dangerous to protect? What process a fire officer uses to decide a structure needs little or no protection? NFA suggest that the answers to these questions depend on more than what the fire does and what resources you have; those answers, to a very large extent, depend on the design and construction of the structure itself and also the other features of the threatened property. This studies focus is to identify specific observations upon which the HFD officer can base triage decisions.

LITERATURE REVIEW

The Structural/Wildland Intermix Problem

With few exceptions, wildland fires in the United States historically had little impact on society because, though sometimes involving vast areas, they typically occurred in wilderness or sparsely populated areas (*Kramer and Bahme,* 1992). During the last twenty years however, resurgence in rural living has dramatically increased the number and area of structural/wildland intermixes, putting more high value properties in just a position with highly combustible vegetation. The result has been an increase exposure to risk, more fires, and striking increases in the loss of lives and structures in intermix areas (*Bailey and Tokle,* 1991). For example, in 1990 and 1991 the largest loss fires in the United States were wildfires in California (*Kramer and Bahme,* 1992*, Taylor and Sullivan,* 1991). Civilians are not the only ones to suffer these increased losses; in 1992, 23.1 percent of firefighter deaths came in wildland fires (*Washburn, LeBlane and Fahy,* 1993*).* (See appendix A).

Structural/wildland intermix fires account for the greatest fire losses in American history, yet development of standards, codes and laws to help regulate the intermix areas has been slow. The fire that over ran Peshtigo, Wisconsin, and surrounding areas in 1871 remains the worst loss of live fire in the United States (*Lyons,* 1976). The Oakland/Berkeley Hills fire that began October 20, 1991 remains the largest dollar loss fire in American history (*Queen,* 1991). Yet, stricter fire safety codes for the structural/wildland intermix is usually enacted only after disaster and then only with difficulty (*Staats and Cutler*, 1991).

Further symptomatic of the general apathy surrounding intermix fire losses is the fact that the first edition of the first National Fire Protection Association (NFPA) standard on protection of life and property from wildfire was issued as recently as 1991 (*National Fire Protection Association* {NFPA}, 1991). Perry (1988) attributes this apathy to incorrect public perception of fire management's, unrealistic public expectations of fire department capability and the failure of the fire service to adequately engage in public education regarding the structural/wildland intermix area.

<u>The Colorado Structural/Wildland Intermix</u>

Over three million acres of wildland subdivisions exist in Colorado, exceeding 4.5 percent of the landmass of a state where almost 18 percent of the population lives in rural areas. Yet uncommon alliance of homeowners, developers and environmentalists has served to undercut the wildland fire mitigation efforts initiated by Colorado fire departments (*Schumacker,* 1990).

In Colorado, efforts to regulate the structural/wildland intermix parallel development of fire and building codes in our urban settings: they arise like a phoenix from the ashes of people's gutted homes. For example, the Olde Stage (arson) Fire in Boulder County that charred over 6,000 acres and destroyed ten houses, was the impetus for the county commissioners to adopt Resolution 91-163 and 92-42 that restricted roof coverings on new or remodeled homes in the mountainous, forested portions of the county (*Cornett and McGrath,* 1990). The 1989 Black Tiger Fire, the wildfire claiming the greatest number of Colorado homes ever, sparked a sixteen month effort in Summit county that culminated in adoption of the most stringent regulations in

Colorado on new construction in the structural/wildland intermix area (*NFPA,* 1991). Existing structures remain largely unregulated. This author felt by reviewing and understanding problems in other areas such as Colorado, it would greatly assist in the production of an operational checklist.

Wildfire Preplanning and Structure Triage

Wildfire preplanning is widely relied upon throughout the country (*Bisbee,* 1993*, Perry,* 1989*).* To differing extents, jurisdictions across the nation rate structures in the intermix area for defensibility and survivability as part of that preplanning process (*Northlake Tahoe Fire Protection district, n.d.:* 1992; *Wrightson,* 1994*).* In Colorado, the rating process, where employed, ranges from simple survey forms (see Appendix C) to computer based, three dimensional color maps showing firefighters which homes they are likely to save and which ones will likely burn (*Lake and Chaffee County Urban/Wildland Interface Wildfire Committees,* 1991*; Lipsher,* 1993*)*.

The importance of the structural/wildland intermix problem has produced a vast body of literature on the subject of wildfire preplanning. That literature is replete with recommendations for structure design, construction materials, landscaping plans and other owner practices intended to lessen the risk inherent in building structures in the intermix area. To a lesser extent, the direct impact of structure and property characteristics on firefighter safety is addressed in the literature. Recommended features and practices are (a) directed to structure survivability without the intervention of suppression forces and (b) tied to the tactic's proven most effective when uncontrollable wildfire present imminent danger to intermix structures (e.g., high mobility of apparatus, exclusive use of tank water, etc.). The literature review of structure survivability factors is summarized in Appendix B and will not be repeated here.

Few sources discuss in detail how to do structure triage under the duress of actual fire conditions. Queen (1992b) provides a comprehensive list of conditions to keep in mind when an interzone fire approaches the area to be defended. However, only Cowardin (1992) outlines a decision making process intended to be employed under fireground conditions. Cowardin's system, named WURST for Wildland/Urban/Rural Structure Triage, established an excellent foundation upon which to build a structure triage approach that the HFD can widely use. The WURST system incorporates the factors identified most often by other authorities reviewed as major factors in the defensibility of intermix structures. WURST also includes set-up time factors not described elsewhere in the literature. WURST, however, does not consider accessibility, escape routes, and other firefighter safety factors in its flowchart model.

In summary, the reviewed literature identifies and gives priority (a) to factors significant in doing structure triage (e.g., defensible space), (b) to factors important to assuring firefighter safety during structure protection (e.g., reliable egress routes), and (c) to factors relevant to tactical considerations (e.g., practical limitations on length of handlines). Factors not indigenous to the WURST model but applicable to typical conditions and situations found in the HFD's response area may be used to create the checklist that represents this project's principle result and output.

PROCEDURES

Definition of Terms

Wildland/Urban Interface. An interface zone is an area where development and wildland fuels meet at a well defined boundary (*National Fire Protection Association,* 1991b).

Wildland/Urban Intermix. An intermix zone is an area where development and wildland fuels meet with no clearly defined boundary (*NFPA,* 1991b).

Structural/Wildland Interzone. The interzone is an area consisting of a wildland/urban interface zone and for a wildland/urban intermix zone. A structural/wildland interzone is particularly descriptive of rural (as opposed to urban) development contiguous or integral to wildland.

Methodology Research

The desired outcome of this research was to create a checklist for use by fire officers performing structure triage during wildfire in structural/wildland interzone. The research was historical in that a literature review was conducted to understand the relationship of building design, materials and landscaping to fire behavior and to firefighter safety. The data was based on fire case studies and on the experience and advice of fire officials, foresters, other public officials, builders and architects.

The research was action research, in that the information gathered through historical research was applied to the actual world problem of structure triage. Structure triage is likely to become necessary in case of a major, uncontrollable structural/wildland interzone fire in the Hopkinsville/Christian County, Kentucky response area. The compilation of structure survivability and firefighter safety factors developed from historical research and embodied in Appendix B was analyzed for (a) the number of occurrences of a particular factor in the referenced sources and (b) each factor's weight or importance as attributed in the references. Subsequently, a checklist was developed for the use by HFD officers and appears as Appendix D.

Assumptions and Limitations

Unlike the WURST triage model (*Cowardin,* 1992), the development of this checklist assumed that triage would not be undertaken unless a scarce resource already exists. Therefore, resource availability was not directly incorporated into the checklist. However, it was also assumed that checklist evaluations need not resulted in an absolute decision about which structures merit or do not merit being defended. Since triage inherently presumes comparison (as well as absolute) evaluation of all threatened structures before assignment of resources, a mathematical comparison of checklist results could be used to decide relative defensibility of multiple threatened structures.

Weather, particularly wind speed, during wildfires is always a major factor in structure survivability and defensibility, largely because high winds cause extensive spot fires (*NFPA*, 1990a). High or gusty winds result in a low probability of success in defending threatened structures (*Perry,* 1990). Applicability of the checklist produced by this research is inversely proportional to wind speed; the checklist is not intended to be a reliable tool when winds exceed 30 m.p.h.

Case histories document that even structures, which meet defensibility criteria to a high degree, cannot be successfully defended in service areas where fire line intensities exceed 500 BTU/feet/second (*NFPA* 1990a). Reliability of the triage checklist would therefore, be suspect if not futile in severe fire areas. There being no convenient technique for field measurement of fire line intensity, responders may be forced into a dangerous, trial-and-error situation where fuel types and densities are likely to result in high fire line intensities. Therefore, the checklist should be used cautiously in areas designated as high wildfire hazard areas by the Kentucky State Forest Service.

Water availability affects the probability of success or failure in structure defense in a threatened area. But is not considered for checklist purposes because, tactical considerations demand high mobility of apparatus, call for water to be applied only from pumper tanks and limit hydrant use to refilling on board tanks (*Bisbee,* 1993*; Cowardin,* 1992*; NFPA,* 1989*; Queen*, 1992b). Therefore, the success of defense of any one structure depends essentially on the decision to defend that structure and the water in the tank(s) of the apparatus committed to that structure. Water availability may determine how many structures are defended in an area within a given period but does not determine the outcome of protective operations at any one specific structure, generally speaking.

RESULTS

A sample checklist produced for assisting with structure triage is shown in Appendix D.

Research question 1. The principal factor jeopardizing firefighter safety while attempting to defend structures in wildland fires is impended of obstructed egress. Standard wildland firefighting orders require that firefighters have at least one and preferably two, reliable escape routes at all times (*Queen,* 1992a). Perry's (1990) warning applied to driveways as well as roads:

> Be very cautious about acres, roads where a good fuel ladder runs from grass to heavy fuel types as well as situations where large "jack pots" of down-dead fuel parallel the road. Flame lengths and thermal outputs in the above examples may exceed survivability and block your egress (p. 286). The narrower the driveway, the greater is the threat from fuel-canopy overhang.

Therefore, NFPA Standard 299 (*NFPA,* 1991b) requires driveways be 12 feet wide in the clear, with a minimum vertical unobstructed clearance of 15 feet. Zeleny (1988) recommends even greater clearances.

Firefighter safety must always be the first consideration (*NFPA,* 1989). Therefore, narrow driveways with fuel-canopy overhangs or proximate accumulations of heavy or down dead fuels contraindicate attack or active defense efforts by emergency responders.

Research Question 2. The foremost predictor of structure survivability is the composition of the roof (*NFPA,* 1980a). The NFPA (c. 1992) states that "the roof is the most vulnerable part of the house in a fire "and that non-combustible roof coverings are a must" (p. 17). "Experience also argues that if a roof is starting to burn, the structure is probably not salvageable" (*Perry,* 1990, p.288). However, experience with the Panorama and Paint fires in California suggests that structures already on fire may be saved if the fire is limited to isolated rooms, decks, eaves or siding and attack lines are quickly deployed (*Perry,* 1990).

The second most important predictor of structure survivability is the presence or absence of adequate defensible space (*Coulter,* 1980*; Cowardin,* 1992*; Lipsher,* 1993*; NFPA,* 199a*; Perry,* 1990). The purpose of defensible space is twofold: to protect structures from approaching wildfire as well as to reduce the potential for a structure fire spreading to the wildland (*NFPA.* 1991b). Structure triage is only concerned with the former purpose. Almost all sources referenced in Appendix B discuss at length requirements for defensible space; those sources differ only in minor ways from each other in their recommendations. All sources agree the minimum diameter of defensible space should be 30 feet. Coulter (1980) and CSFS (1991) provide quantitative recommendations for expanding defensible space to compensate for steeper slopes.

The third most significant survivability predictor is a combination of slope and terrain. The NFPA (1991b) defines steep slope as those exceeding 20 percent (ratio of rise to run) and extreme slopes as those exceed 40 percent. NFPA statistics, based on case studies, predict an unsuccessful outcome for structure defense when slopes surrounding the structure exceed 20 percent (*NFPA*, 1990a). Queen (1992a; 1992b) and other authorities cited in Appendix B. Items 2 and 17, also discuss the increased hazard from fire to which structures located in saddles, at the top of steep slopes, on ridges and at the top of ravines are exposed. Cowardin (1992) also recommends considering the difficulties the given terrain will cause firefighters in stretching and maneuvering attack lines.

Other physical features of structures and land frequently cited by authorities are having great influence on the probability of success (or failure) in structure protection operations include the following (see Appendix B):

- Access roads and driveways (dead-ends, length, width, slope, grade, surface, turnarounds)
- Exterior construction (non-combustible, fire resistive or combustible)
- Projections, overhangs and stilt construction
- Windows and other glazed openings (size, thickness and protection)
- Vents and other opening into attics or foundations (presence or absence of screens)
- Fuel loading on land adjoining defensible space (type and amount of vegetation)
- Fuel stored within the defensible space (firewood, LPG, etc.)
- Above ground power lines crossing over structure or defensible space

Research Question 3. Fire officers doing triage may have to do so from access roads, in smoky conditions and sometimes even in the dark. Therefore, evaluation criteria must be carefully limited to those that may be assessed quickly and easily under adverse conditions. Roof composition may be difficult to identify under such circumstances, but must be assessed neverless because of its major import to defensibility. Qualitative assessment of defensible space is usually more easily achieved than roof assessment. Whether the slope does or does not exceed 20 percent around the structure may be judged with little or no training. The position of a structure in an unfriendly location, such as at the top of steep slopes, is typically obvious. Projections, such as balconies and decks, are normally readily observable, as is stilt construction. Also, the presence of major power lines or even service drops is usually known or readily observable if adequate defensible space has been provided.

Factors more difficult to assess by observation from a distance include windows, attic vents, fuel loading adjacent to defensible space and on site fuel storage. The size of windows is often apparent, but window composition and protection are not so apparent. LPG tanks, firewood, and comparable materials may not be visible from the one or two observation points from which a fire officer is likely to be performing triage. Three hundred sixty-degree reconnaissance will probably not be feasible due to time and distance limitations and due to the number of structures to be evaluated. Lacking information gathered from such investigation, detailed information about debris on roofs, attic vents and exterior construction materials will, in all likelihood, be unavailable for triage purposes.

Research Question 4. The checklist includes guidelines for triage decision making based on the number of compromising characteristics found at the property. Low scores suggest the structure will probably survive without intervention. Mid-range scores suggest the structure should be defended. High scores suggest the structure is probably not salvageable even with intervention. The decision making guidelines are approximate and based on outcomes reported for structures having similar characteristics in a number of major interzone fires *(Birr,* 1990, 1992*; Cornett, McGrath and Mcallister,* 1990*; Cornett, Narvaes and McCrath,* 1990; *Cullom,* 1990*; Hoffman,* 1991*; Hutchinson,* 1990; *Hutchinson and Narvaes,* 1990*; Lipsher,* 1993*; Michaels,* 1991*, NFPA,* 1990a, 1990b*,* 1992*; Staats and Cutler,* 1991*, Sunderland,* 1992).

Checklist Rationale

The checklist is organized into three sections based on order of use. The first section, the safety section, identifies those features intended as prohibitions to further triage or structure protection. The characteristics assessed involve access to and existing fire conditions of the structure.

The second section assesses ten of the most important safety, survivability and defensibility factors using a yes or no format (see Appendix D). The **DRIVEWAY** assessment is both a safety consideration and a predictor of survivability (*NFPA,* 1990). Weighing in favor of the more important elements of triage (e.g., roof composition, and defensible space) is accomplished by using multiple evaluations for the same triage factor or elements. This approach is exemplified by two **ROOF** questions, a **TREES** questions (that overlaps roof and separation triage elements) and two additional questions about defensible space (TREES and BRUSH and VEHICLES). **SLOPE** has two assessments that combine the triage factor of terrain slope with the factor of site location: structures on ridges, hilltops, etc., typically have steep terrain nearby. The **SLOPE** questions also address ruggedness of terrain that would impede defensive operations. Even structures located at the bottom of a hill (i.e., toe of slope) are difficult to defend if firefighters have to climb steep embankments. Finally, two questions regarding ancillary triage elements are included. These two elements, DECKS or STILT

CONSTRUCTION and POWER LINES were chosen because they are usually easy to observe even from a distance.

The last section of the form provides a place for the triage officer to score the structure and provides decision-making quidance based on that score. Four categories of quidance were used so marginal situations, requiring special attention; to escape routes could be distinguished from less threatening circumstances.

DISCUSSION

The checklist which represents the results of this research reflects Cowardin's (1992) structures triage model and embodies the consenses recommendation of the authorities referenced in Appendix B. These authorities also site a variety of other factors as being of importance to the survivability of a structure during a wildland fire. However, brevity and simplicity demand practical limitations on the number of items evaluated during structure triage. Triage officers, using the checklist, should not necessarily limit their considerations only to those found on the form. Triage officers should possess knowledge encompassing at least all factors listed in Appendix B.

The checklist (Appendix D) should be of considerable value to fire officers performing triage during structural/wildland interzone fires. However, fire officers using the proposed triage checklist should temper their decision to defend or not defend a structure with judgement founded on experience. Unfortunately, most Christian County fire officers will not possess experience sufficient to have good judgement about structure triage. The value and importance of having such a checklist increases under these circumstances.

Because the checklist guidelines are merely untested recommendations based on a synthesis of information gathered in this research, triage officers need to be aware that the true probability of successfully defending a structure from wildfire is a matter of infinite complexity, uncertainty and the ability to accept change. Queen (1992b) discusses the shortcomings of practical fire prediction methods; these methods have very limited applicability to structure protection during wildland fires. Over optimistic predictions too often have resulted in unsuccessful attempts to save a few structures. Write-offs would have given suppression forces time to gather in strength further in advance of the fire where firefighting efforts would have likely stem fire advance and therefore, eliminate the need to defend individual structures.

The proposed checklist is the first of its kind customized for use by the Hopkinsville, Christian County Fire Department. Selection of evaluation criteria was much influenced by conditions common to Christian County. As is true of the resources prepared for use during disasters, this author hopes the checklist need never be used under actual wildfire conditions. Nevertheless, the checklist adds another weapon to the HFD's arsenal. This study has hopefully produced an instrument comparable to the worksheets used by Incident Commanders as an aide in managing structure fires and hazardous materials incidents. If nothing else, the checklist will serve to jog the minds of fire officers burdened with the responsibility of making critical decisions in compressed time frames and without full and complete fireground data.

The development of this checklist as proven, by using the change management model approach taught at the NFA changes can be less pointless and effective. This checklist has also fostered the team approach that is required in the firefighting industry.

RECOMMENDATIONS

Department procedures for managing wildfires in the structural/wildland interzones should incorporate use of the structure triage checklist. HFD should integrate use of the checklist in its training and assure that the form is readily available for instant use, in the event subdivisions are endangered. Training in checklist use should include clear instruction as to the limitations and dangers inherent in trying to apply a single set of structure triage criteria in any and all wildfire situations. Written instructions explaining the use of the form should be developed to facilitate training.

Previous review and revision of the form should be undertaken to keep the checklist up to date. New ideas, based on local circumstances, may drive alterations to the form. Additionally, the form should reflect future changes to NFPA 299 as well as changes to the Christian County Fire Hazard Mitigation Program.

As the form matures and evolves through training, review and revision, the Christian County Fire Chief should consider adopting the checklist or its successor countywide. Benefits from such standardization have already been realized in such diverse areas as fire prevention and fire safety, pump operation and procurement. Structure triage should be added to that list.

Finally, the factors listed in Appendices B and D should become the basis of an evaluation checklist used for structure preplanning in the interzone. HFD would benefit from that preplanning by having a more accurate assessment of the latent service demands, assumed risks and tactics needed. Property owners would benefit from such evaluations by gaining knowledge about methods to improve the survivability of their buildings and for reducing the probability that a fire in their building will extend to the surrounding wildland and bring them the concomitant liability. A property owner could also be put on notice that his/her home or structure will be a write-off during a widespread, uncontrollable wildland fire unless the owner takes corrective action. That information should lead to citizens having more realistic expectations of the HFD's capabilities to provide protection in the structural/wildland interzone.

This information should also lead fire officers to resist the reluctance to changing procedures.

Change has always been with us, and it will continue to be with us.

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APPENDIX A
Structural/Wildland Interzone Fires

YEAR	NAME/LOCATION	LOSS
1871	Peshtigo, Wisconsin	1,500 fatalities 3 towns destroyed
1894	Hinkley, Minnesota	418 fatalities 1 town destroyed
1901	Jacksonville, Florida	1,700 structures
1923	Berkeley Hills, California	584 homes
1929	Great Mt. Tamalpais Fire, Mill Valley, California	117 homes
1956	Newton Fire, Los Angeles County, California	50 structures
1961	Harlow Fire, Mariposa County, California	106 structures
1961	Bel Air Fire, Los Angeles, California	500 homes
1963	New Jersey Pine Barrens	380 homes
1964	Hanley Fire, Santa Rosa, California	224 homes
1964	Coyote Fire, Santa Barbara, California	94 structures
1967	Paseo Grande, Riverside County, California	61 structures
1970	Series of 773 Fires, California	722 structures
1970	Bear Fire, San Bernardino County, California	54 structures
1970	Oakland Hills, California	37 homes
1977	Sycamore Fire, Santa Barbara, California	234 homes
1978	Bell Canyon, Los Angeles, California	30 homes
1978	Creighton Ridge Fire, Sonoma County, California	64 structures
1980	Stable Fire, San Bernardino County, California	65 structures
1980	Summit Series, San Bernardino County, California	355 homes
1981	Atlas Peak Fire, Napa County, California	69 structures
1982	Dayton Haul Fire, Los Angeles County, California	65 structures
1985	Lehr Fire, San Diego County, California	64 structures
1985	Palm Coast Fires, Flagler County, Florida	2 fatalities 200 homes $100 million
1987	Hangman Hills, Washington	22 homes $8 million
1988	49er Fire, Nevada County, California	312 structures
1988	Fern Fire, Shasta County, California	58 structures
1988	Baldwin Park, Los Angeles, California	15 homes
1989	Black Tiger Fire, Boulder County, Colorado	44 homes $10 million
1990	Stephan Bridge Road Fire, Crawford County, Michigan	201 structures $6 million

APPENDIX A
Structural/Wildland Interzone Fires

YEAR	NAME/LOCATION	LOSS
1990	Dude Fire, Tonto National Forest, Arizona	6 fatalities 65 homes $12 million
1990	Paint Fire, Goleta, California	1 fatality 641 structures $500 million
1990	Glendale Fire, Los Angeles County, California	50 structures
1990	"A" Rock Fire, Mariposa County, California	66 structures
1990	Wasatch Mountain Fire, Midway, Utah	2 fatalities 49 structures $2.5 million
1990	Bend, Oregon	21 homes
1990	Olde Stage Road Fire, Boulder, Colorado	15 structures
1991	Spokane, Washington	1 fatality 100 homes
1991	Oakland/Berkeley Hills Fire, California	26 fatalities 1 firefighter death 3,132 dwellings $1.5 billion
1992	Calaveras County, California	117 structures
1993	Laguna Hills Fire, Orange County, California Malibu Fire, Los Angeles, California Old Topanga Fire, Los Angeles, California	1,000 homes

APPENDIX B

Structure-Survivability Factors

FACTOR	REFERENCES
1. Fuel Hazard Rating of Property Light (grass, weeds, shrubs) Medium (brush, large shrubs, small trees) Heavy (woodland, timber, heavy large brush) Thinning conducted in surrounding forest	Board of County Commissioners [BOCC], 1992 Colorado State Forest Service [CSFS], 1991 National Fire Protection Association [NFPA], 1991b Perry, 1990 Queen, 1992b Winston, 1992 Zeleny, 1988
2. Slope Hazard Rating Good slopes, <20% Bad slopes, ≥20%	Coulter, 1980 Cowardin, 1992 CSFS, 1991 National Fire Protection Association [NFPA], 1990a NFPA, 1991b National Fire Protection Association [NFPA], c. 1992 Oregon State Department of Forestry [OSDF], 1988 Perry, 1989 Perry, 1990 Swinford, Tokle, Bethea & Erb, 1991 Winston, 1992 Zeleny, 1988
3. Roof Material Noncombustible Fire retardant (Class A, B, or C)	BOCC, 1992 Coulter, 1980 Cowardin, 1992 CSFS, 1991 Kluver, 1992 NFPA, 1990a NFPA, 1990b NFPA, 1991b NFPA, c. 1992 OSDF, 1988 Perry, 1989 Perry, 1990 Queen, 1992b Swinford et al., c. 1988 Winston, 1992

APPENDIX B

Structure-Survivability Factors

FACTOR	REFERENCES
4. Exterior Construction Noncombustible Fire resistive	BOCC, 1992 CSFS, 1991 Kluver, 1993 NFPA, 1990a NFPA, 1990b NFPA, 1991b NFPA, c. 1992 OSDF, 1988 Perry, 1990 Swinford et al., c. 1988 Winston, 1992
5. Clearance from Vegetation (Defensible Space) Trees & brush are thinned Roof & gutters clear of debris Trees do not overhang any roof Ladder fuels are pruned Grass/Weeds mowed Trash, litter, & debris removed No vehicles parked near structure Clearance around LPG tanks or flammable liquid storage Adequate separation between structures	BOCC, 1992 Coulter, 1980 Cowardin, 1992 CSFS, 1991 Kluver, 1992 NFPA, 1990a NFPA, 1990b NFPA, 1991b NFPA, c. 1992 North Lake Tahoe Fire Protection District (NLTFPD), 1991 OSDF, 1988 Perry, 1990 Queen, 1992b Swinford et al., c. 1988 Zeleny, 1988
6. Access Roads & Driveways Number of access routes Width Vertical clearance Grade Curve radius Dead-end distance Turnarounds All-weather surfaces Intersections No fuel-canopy overhangs	BOCC, 1992 Coulter, 1980 CSFS, 1991 NFPA, 1990a NFPA, 1991b NFPA, c. 1992 OSDF, 1988 Perry, 1989 Perry, 1990 Queen, 1992b Swinford et al., c. 1988 Zeleny, 1988

APPENDIX B

Structure-Survivability Factors

FACTOR	REFERENCES
7. Water Supplies	BOCC, 1992 Coulter, 1980 CSFS, 1991 NFPA, 1990a NFPA, 1991b NFPA, c. 1992 OSDF, 1988 Perry, 1990 Queen, 1992b Zeleny, 1988
8. Vents (screened) Attic Foundation	Coulter, 1980 CSFS, 1991 NFPA, 1990a NFPA, 1990b NFPA, 1991b OSDF, 1988 Swinford et al., c. 1988
9. Overhangs/Stilt Construction (fire-resistive enclosures) Eaves Decks Porch Balcony Carports Patio covers Roof overhangs Combustible storage under decks, stairs, & eaves	BOCC, 1992 Coulter, 1980 CSFS, 1991 Kluver, 1992 NFPA, 1990a NFPA, 1990b NFPA, 1991b NFPA, c. 1992 NLTFPD, 1991 OSDF, 1988 Swinford et al., c. 1988 Zeleny, 1988
10. Glazed Openings Protected (shutters, fire-resistant drapes, etc.) Small, double-pane windows	CSFS, 1991 NFPA, 1990b NFPA, 1991b NFPA, c. 1992 OSDF, 1988 Swinford et al., c. 1988
11. Sprinkler Systems	BOCC, 1992 NFPA, 1990b
12. Building/Lot Size	BOCC, 1992 Perry, 1989 Zeleny, 1988

APPENDIX B

Structure-Survivability Factors

FACTOR	REFERENCES
13. Firewood Stacked Properly Uphill Away from structure	Coulter, 1980 CSFS, 1991 NFPA, c. 1992 NLTFPD, 1991 OSDF, 1988 Swinford et al., c. 1988
14. Power/Telephone Lines Underground preferred Limbs kept clear of aboveground lines	Coulter, 1980 CSFS, 1991 NFPA, c. 1992 NFTFPD, 1991 OSDF, 1988 Swinford et al., c. 1988
15. Roof Shape	Coulter, 1980 CSFS, 1991
16. Vegetation Type	Coulter, 1980 NFPA, 1990 NFPA, c. 1992
17. Poor Locations/Terrain Saddles Top of steep slopes On ridges Top of ravines or chutes Rough terrain for firefighting	Cowardin, 1992 NFPA, 1990a OSDF, 1988 Queen, 1992b Swinford et al., c. 1988 Winston, 1992
18. Home Burning? (involvement)	Cowardin, 1992 Queen, 1992b
19. Time Before Arrival of Fire Front	Cowardin, 1992
20. Rescue (structure occupied)	Queen, 1992b

WILDFIRE HAZARD RATING FORM
-SUBDIVISION-

NAME OF SUBDIVISON: ______________________ DATE ____________
COUNTY ____________ SIZE (AC) ____________ #LOTS ____________
RATING ____________ COMMENTS ______________________

A. SUBDIVISION DESIGN

1. Ingress/Egress:
   - Two or more roads, primary routes — 1 ____
   - One road, primary route, plus alternate — 3 ____
   - One way in/out — 5 ____
2. Primary Road Widths:
   - Minimum 24 ft. — 1 ____
   - Less than 24 ft. — 3 ____
3. Accessibility:
   - Smooth road, grade less than 5% — 1 ____
   - Rough road, grade less than 5% — 3 ____
   - Other — 5 ____
4. Secondary Road Terminus:
   - Loop roads or cul-de-sacs w/turn-around radius greater than 45 ft. — 1 ____
   - Cul-de-sac turnaround radius less than 45 ft. — 2 ____
   - Deadend roads less than 200 ft. in length — 3 ____
   - Deadend roads over 200 ft. in length — 5 ____
5. Average Lot Size:
   - More than 10 acres — 1 ____
   - Between 1 and 10 acres — 3 ____
   - Less than 1 acre — 5 ____
6. Street Signs:
   - Present — 1 ____
   - Not present — 5 ____

B. VEGETATION

1. Fuels/Density (General): 1 ____
   - Grass with scattered trees or oak brush — 3 ____
   - "Thinned" conifers (10 ft. or more between trees) — 5 ____
   - Sagebrush/willow — 7 ____
   - Moderately dense conifers or oak brush
   - Dense, continuous conifers and/or thick oak brush — 10 ____
2. Defensible Spaces Completed:
   - More than 70% of sites — 1 ____
   - Between 30-70% of sites — 5 ____
   - Less than 30% of sites — 10 ____

C. TOPOGRAPHY

1. Slope (Predominant):
   - Less than 8% — 1 ____
   - Between 9-20% — 4 ____
   - Between 21-30% — 7 ____
   - Greater than 31% — 10 ____

D. FIRE PROTECTION

1. Response Time:
   - Within 15 minutes — 1 ____
   - Within 16-30 minutes — 5 ____
   - Greater than 31 minutes — 10 ____
2. Hydrants:
   - 500 gpm hydrants on less than 1000 ft. spacing — 1 ____
   - Hydrants, but less than above or pump-site available on-site — 2 ____
   - No hydrants or pump-site — 3 ____
3. Draft Sources:
   (Complete only if no hydrants or pump-site available)
   - Draft sources within 20 minutes round-trip — 1 ____
   - Draft sources within 21-45 minutes round-trip — 5 ____
   - Draft sources greater than 46 minutes round-trip — 10 ____

E. STRUCTURE HAZARD

1. Materials (Predominant):
   - Roof and siding materials non-wood — 1 ____
   - Flammable siding/non-flammable roof (includes mobile home) — 5 ____
   - Flammable roof — 10 ____

F. UTILITIES (Gas and/or electric)

1. Placement:
   - All underground — 1 ____
   - One underground, one aboveground — 3 ____
   - All aboveground — 5 ____

TOTAL FOR SUBDIVISIONS

Low Hazard	0-29
Moderate Hazard	30-39
High Hazard	40-48
Severe Hazard	49-59
Extreme Hazard	60+

APPENDIX D

STRUCTURE-TRIAGE CHECKLIST

ADDRESS OR DESCRIPTION: ____________________

		YES	NO
DRIVEWAY	TOO NARROW OR STEEP TO BACK IN OR BRANCHES OVERHANG DRIVEWAY OR DOWN-DEAD FUELS LINE DRIVE		
ROOF	ALREADY INVOLVED IN FIRE		

IF YES CHECKED FOR EITHER ABOVE, STOP! WRITE OFF!

TRIAGE OFFICER: ____________________

	YES	NO
DRIVEWAY DEAD-END & LONGER THAN 200 FT		
ROOF COMBUSTIBLE (ASPHALT SHINGLES OR WOOD)		
ROOF WOOD SHAKES		
TREES OVERHANG ROOF		
TREES AND BRUSH NOT THINNED THROUGHOUT AREA WITHIN 30 FT OF STRUCTURE		
VEHICLES PARKED OUTSIDE WITHIN 3O FT OF STRUCTURE		
SLOPE OF TERRAIN MORE THAN 20% ANYWHERE WITHIN 3O FT OF STRUCTURE		
SLOPE OF TERRAIN MORE THAN 40% ANYWHERE WITHIN 5O FT OF STRUCTURE		
DECKS OR STILT CONSTRUCTION NOT ENCLOSED UNDERNEATH (TO GROUND)		
POWER LINES ABOVEGROUND WITHIN 30 FT OF STRUCTURE		

NUMBER OF YES CHECKS ______

YES	
0-2	DOESN'T NEED DEFENDING
3-5	DEFEND AGGRESSIVELY
6-7	DEFEND CAUTIOUSLY
8-10	WRITE OFF!

WRITE OFF SOONER IF WIND SPEEDS ARE OVER 30 MPH